Use of Seasonal Climate Forecasts in Rangeland-Based Livestock Operations in West Texas

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ABSTRACT

The potential for west Texas ranchers to increase the profitability of their enterprises by becoming more proactive in their management practices by using seasonal climate forecasts is investigated using a focus group and ecological–economic modeling. The focus group felt forecasts could potentially be used in making decisions concerning stocking rates, brush control, and deer herd management. Further, the focus group raised concerns about the potential misuse of "value-added" forage forecasts. These concerns necessitate a revisiting of the value-added concept by the climate-forecasting community. Using only stocking-rate decisions, the potential value of seasonal forage forecasts is estimated. As expected, the economic results suggest the value of the forecasts depends on the restocking and destocking price along with other economic factors. More important, the economic results and focus-group reactions to these results suggest the need for multiyear modeling when examining the potential impact of using improved climate forecasts.

1. Introduction

The economic viability of rangeland-based livestock enterprises is critically affected by management's ability to cope with climate variability. Most ranchers' management styles are reactive, making adjustments to their operations only after climate conditions are experienced. Improved seasonal climate forecasts may allow ranchers to be more proactive in managing their rangeland resources. If a drought is forecast, for example, then herd size could be adjusted, which may allow for less expensive drought-coping alternatives and may help to avoid ecological deterioration of the range. Similar, if wetter-than-average conditions are forecast, ranchers may want to purchase additional cattle. Proactive management using seasonal climate forecasts may help decision makers to mitigate poor conditions and take advantage of good conditions (Stern and Easterling 1999).

Seasonal climate outlooks with lead times of up to 13 months are currently being disseminated (O'Lenic 1994; Mason et al. 1999). The basis for these outlooks is the substantial scientific advancements made in understanding the climate system and technology in the last part of the 20th century (Hill 2000). A well-known example of these advancements is our increased understanding of the El Niño–Southern Oscillation (ENSO) phenomenon (Glantz 1996; Trenberth 1997). Other climate forcing factors with the potential to improve seasonal climate outlooks include the North Atlantic oscillation, Pacific–North American quasi-biennial oscillation, and solar cycles (Mjelde et al. 1998). Studies suggest these outlooks are more skillful than climatological (historical) probabilities (Livesey 1990; Wilks 2000a). Wilks (2000a) provides indications that the revised (revision occurred in December of 1994) Climate Prediction Center probabilistic temperature and precipitation outlooks are improvements over their previous outlooks, thus providing further evidence that our ability to provide useful seasonal climate outlooks is improving.

Previous studies suggest decision makers in many different sectors of the economy may benefit from ENSO-based and improved climate forecasts [see Mjelde et al. (1998), Nicholls (1996), Global Climate Observation Systems (1995), and Wilks (1997) for reviews of this literature]. One area that has received little attention in this literature is how the use of improved climate forecasts may influence rangeland management

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decisions. In a discussion piece, Stone (1994, p. 103) states "ideally, grazers should be able to match stocking rates to seasonal conditions so that animal production is maximized and damage to pasture and land production is minimized." Several recent studies in Australia suggest ranchers may have the flexibility to use seasonal climate forecasts to help to manage risk and improve long-term profitability (Johnson et al. 2000; Ash et al. 2000; Stafford-Smith et al. 2000). Johnson et al. (2000) stress rangeland operations are different from croplands and a long-term approach to valuing climate forecasts is necessary. Although benefits the use of seasonal forecasts are shown, Ash et al. (2000) conclude decision makers are reluctant to accept and use such forecasts. Stafford-Smith et al. (2000) conclude current seasonal forecasts have some value but future developments promise even more value.

This study investigates the potential for ranchers to increase the profitability of their enterprises by becoming more proactive in their management practices with the increased availability of seasonal climate forecasts. The study's specific objectives are twofold. First, factors affecting the use of seasonal climate forecasts in ranching enterprises in west Texas are determined through the use of a rancher focus group. Second, the potential economic values of seasonal climate forecasts are obtained using input from the focus group and biophysical–economic modeling. Unique to this study is the use of decision rules based on input from a focus group of decision makers rather than model-based decision rules to value climate forecasts.

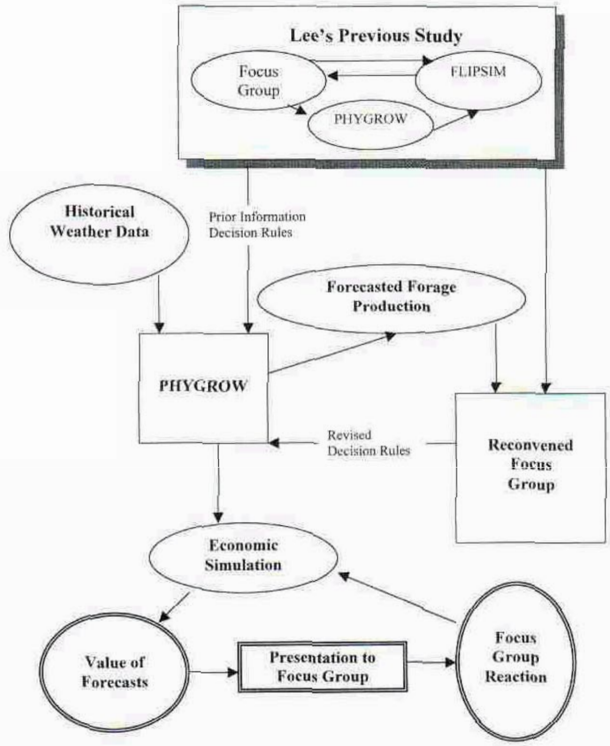

FIG. 1. Simplified flow-chart representation of the study.

2. Materials and methods

The study's procedures are outlined in Fig. 1. A focus group of ranchers previously used by Lee (1999) was reconvened to elicit additional decision-making information. The seven focus group members were commercial-scale ranchers in the area. They were selected by Texas Agricultural Experiment Station scientists based on their willingness to participate in technology development and implementation. The reconvened focus group was presented climate forecast information. Included in this presentation were the potential impacts of different climate conditions on forage production. After discussing the probabilities and risks associated with the forecasts, the ranchers were asked to evaluate the stocking-rate decision rules developed by Lee (1999) to see what changes, if any, would be made after the forecast information is considered. Following an iterative process, a consensus was reached. Forage production and livestock performance are simulated by the phytomass growth simulator (PHYGROW) using prior knowledge [from Lee's (1999) study] and revised (from reconvening the focus group) decision rules. Results from PHYGROW are used in an economic model of net returns per section (259 hectares) based on work by Lemberg (2000). Net returns obtained using the base and revised decision rules are used to evaluate the economic impacts of using the climate forecasts. Initial results were presented to a second reconvening of the focus group. The focus group's reactions regarding initial results were then incorporated. The reader is referred to Lee (1999) for details of the representative range–ecological model and to Jochec (2000) for details of the current study.

a. Biophysical simulation model—PHYGROW

PHYGROW uses weather, soil, plant, and herbivore inputs for a specified range site to simulate livestock and forage production (Ranching Systems Group 1995). Weather parameters include daily temperatures, precipitation, and solar radiation. Soil characteristics include surface slope, soil depth, density, and water content. Plant inputs consist of plant species and growth attributes, such as leaf area index, canopy height, rooting depth, and energy-to-dry-matter conversion rate. Herbivore characteristics are the animal species on the range site and each species's grazing preferences. PHYGROW simulates forage production and resulting animal production, stocking rates, weaning weights, and calf crops, which are then used in the ranch economic model.

Soil, plant, and herbivore parameters representative of Sutton County in west Texas are used. Besides the importance of ranching to this county, two additional reasons for using this area are the willingness of ranchers in this area to participate and the availability of a range–ecological model for this county [developed by Lee (1999) using PHYGROW]. Sutton County consists primarily of Tarrant and Kavett soils that are associated with the Low Stony Hill and Shallow range sites. The Low Stony Hill and Shallow range sites are simulated separately by PHYGROW. Livestock performance is weighted by the proportion of each site in the county for input into the economic model. Stocking rates presented to the focus groups are in animal units per section, a common measure used by ranchers. Grazing pressure equivalent to one animal unit is 12 kg of forage dry matter per day

b. Focus-group meetings

The reconvened focus-group meeting was conducted at the Sonora Experiment Station on 21 January 2000. After a welcome to the meeting, attendees were thanked for their past and current participation in the focus group. The focus group conversed for four hours, including a lunch in which the conversation continued. Immediately following the meeting, the study team members met to discuss and compare notes. Three days after the meeting, the members met again to form a consensus on the information obtained from the focus group. Preliminary results were presented to the focus group on 2 August 2000. Again, immediately following this meeting, the study team members met to discuss and compare notes. This second meeting was less structured than the first, concentrating on the economic model development and interpretation of the results.

At the initial focus-group meeting, the ranchers were presented with a packet of information on Lee's (1999) study, climate forecasts, and the new study. An overview of the previous project's results was presented. To link the ranchers' past participation with the current meeting, decision rules developed from the last meeting were reviewed. Besides the decision rules, the ranchers were also briefed on the complexity of the PHYGROW model. Following this overview, the ranchers were presented with background information on climate forecasting. Background information started with defining seasonal climate forecasts. The availability of outlooks was also briefly discussed. Examples of the Climate Prediction Center's seasonal climate outlooks were presented to the ranchers to display the varying types of information currently available. The ENSO phenomenon was also discussed. Key points of the climate outlook presentation were: 1) outlooks are not a certainty, 2) current outlooks have more skill than using historical averages, 3) climate forecasting will continue to improve with technological advancements and as our understanding of the climate system increases, and 4) there is a strong push to make seasonal outlooks more user friendly. The information from the previous study and the climate outlook information were intended to give the ranchers appropriate contextual background material, an integral part of conducting a focus-group meeting (Nicholls 1999; Greenbaum 1998).

Ranchers at the second meeting were presented with a packet of information that included a review of climate and forage forecasts, the study team's interpretation of the information discussed in the previous meeting, a representation of the economic model, and initial results. Information discussed in the first meeting was reviewed. Discussion at the second focus-group meeting concentrated on the appropriateness of the revised decision rules given the seasonal forecasts, development of the economic model, and economic results.

c. Seasonal forage-production forecasts

Seasonal forage-production forecasts are used to represent climate conditions. Several reasons contribute to the use of forage forecasts. First, using rainfall forecasts can be misleading. For example, 2 in. of total monthly rainfall can result in different forage productions. If the 2 in. occurred on the first day of the month, poor growing conditions may be realized for most of the month. On the other hand, if the 2 in. is more evenly distributed throughout the month, more favorable growing conditions are experienced. Transforming daily weather data into forage-production forecasts is one possible way to alleviate this daily weather variability problem. Second, Wilks (2000b, p. 1965), discussing currently available temperature and precipitation forecasts, notes, ". . . the forecasts as issued do not directly provide the information needed by many decision makers. Consequently, value-added interpretations of the forecasts will often be necessary in order for them to be used most effectively." Last, in the climate forecasting community there is a push to provide user-friendly forecasts. In general, it is perceived by the climate forecasting community that specific forecasts for temperature and rainfall do not provide as much value as forecasts for variables such as forage production that directly affect decision makers. Use of forage production is an attempt to provide user-friendly, valued-added seasonal climate forecasts.

Forage-production forecasts are based on forage deviations from the long-term mean. Three categories of forage production are used: above-average, typical, and below-average forage production. To obtain these forecasts, the following procedure is used. Daily weather data for Sonora, Texas, from 1949 to 1998 are used in PHYGROW along with soil characteristics, plant attributes, and the stocking-rate decision rules from Lee (1999) to obtain daily forage production for each year. Representative above-average, typical, and below-average forage-production years are chosen using a two-part process. The first step of the process determines the forage categories for each year. To accomplish this categorization, for each day, deviations in available forage from the long-term daily average are calculated. These daily deviations are then summed for each year.

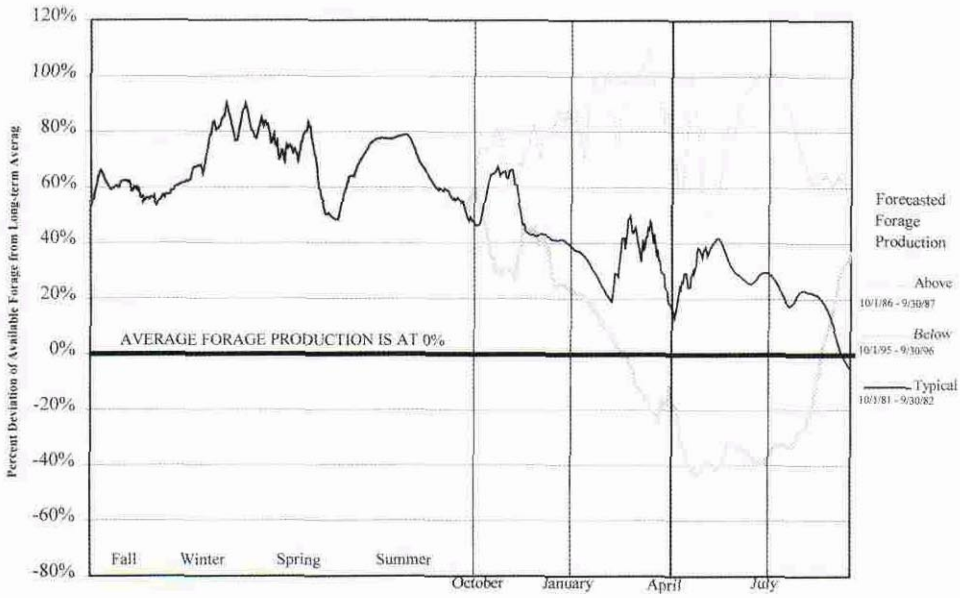

FIG. 2. Available forage as a percent deviation of the long-term average following an above-average year (1 Oct 1986–30 Sep 1987) of forage production.

Years in which the summed yearly deviations are greater (less) than the mean yearly deviation plus (minus) one-half standard deviation of the yearly forage deviations are classified as above (below) average. Approximately 24% of the years fall into the above category, whereas 45% and 31% fall into the typical and below average years of forage production. The second part of the year-choosing process identifies a representative year for each category. Years chosen as representative of their categories are 1 October 1986–30 September 1987 for above, 1 October 1981–30 September 1982 for typical, and 1 October 1995–30 September 1996 for below. Two criteria were used for choosing the representative years: 1) the years had to be "median" years in their respective groups and 2), if possible, the years also had to fall in the recent past for ease of recollection to the rancher. Daily forage deviations were converted into percent deviations of available forage from the long-term average and smoothed using a 10-day moving average. Graphs of the smoothed forage-deviation values were presented to the focus group as available forage-production forecasts. One reason the above scheme was used is because classifying forage production by ENSO (the most prevalent base for climate forecasting systems today) did not provide enough information for decision making. This observation was confirmed by the focus group.

The focus group was shown two different forecast scenarios, "no uncertainty" and "uncertainty." In addition, because current range conditions are important, each scenario also depends on current conditions. Current conditions are given by the representative years for above-average, typical, and below-average forage production. To clarify, consider Fig. 2, a reproduction of one graph presented to the focus group (colorized versions of the figures were presented to the focus group). The left-hand side of Fig. 2 represents a current year in which above-average forage production was experienced. Focus group members were told this part of the graph represented forage production for the year of 1 October 1986 to 30 September 1987 to provide an analog year to help understand the current forage conditions. When presented with these graphs, the ranchers were reminded of the stocking decision rules based on Lee's focus-group meeting at which no forecasts were available. Further, they were told to assume the forecast conditions would occur, that is, there is no uncertainty in the forecasts. The ranchers were then asked to look at the right-hand side of Fig. 2, which represented the three possible forage forecasts for the following year. Note in Fig. 2, as previously discussed, the daily weather generating the current above-normal and forecast above-normal years is the same year, 1 October 1986–30 September 1987. Questions were asked about their potential use of each of the three forecasts, given the current year is above-average forage production. These questions were designed to obtain the ranchers' perceptions and willingness to alter their decisions. All ranchers were asked questions concerning their use of the forage forecasts, along with attempts to reach a consensus. Note that the ranchers were not asked to give a specific stocking rate but rather the directions and strength of their changes. A consensus was reached as to the direction and strength of any changes. Similar graphs for typical and below-average current-year cases were shown to the focus group.

In the uncertainty scenario, colored versions of nine graphs were presented. Each current year was followed by various forage forecasts associated with years of

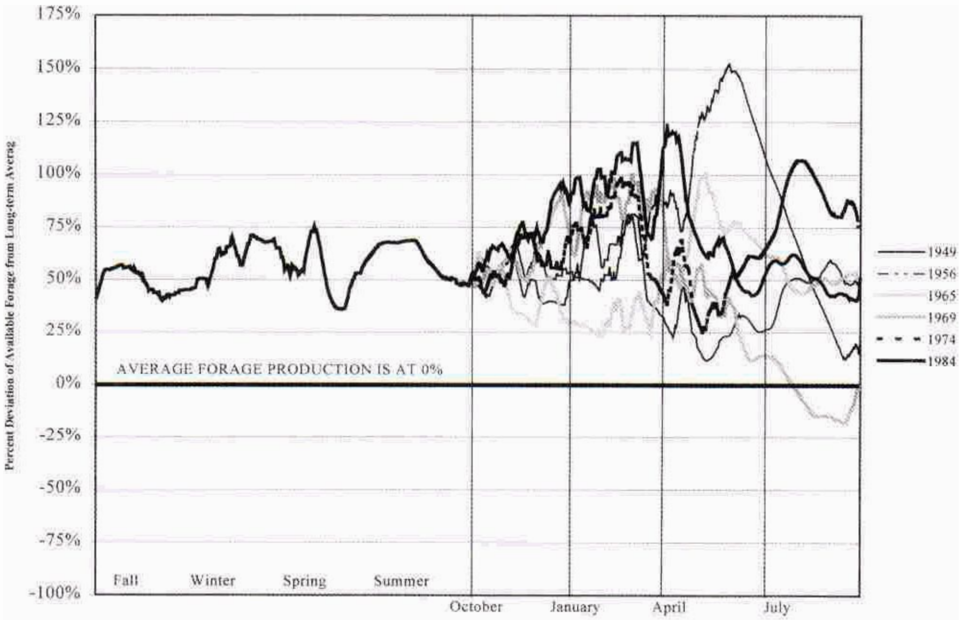

FIG. 3. Above-average years of available forage as a percent deviation of the long-term average following an above-average year (1 Oct 1986–30 Sep 1987) of forage production.

above-average, typical, and below-average forage production. The uncertainty graphs contained only some years in each of the forecast categories. Not all years in any one category were presented because of the difficulty in interpreting the graphs given the number of years contained in each category. As an example, Fig. 3 represents an above-average current year with an above-average forecast. The focus group was told the graphs represent the range of forage production that could be expected when a specific forage forecast is received. Again, a consensus was reached concerning the use of the forecast when the forecast is uncertain and a range of forage conditions can be expected.

d. Economic model

Using decision theory (Hilton 1981), the value of the seasonal climate forecasts is obtained by comparing two scenarios: 1) what would take place if only prior information is used and 2) what will occur if the climate forecasts are used (Mjelde et al. 1988). Expected annual net returns per section obtained from using Lee's (1999) stocking-rate decision rules represent the prior information scenario. The use of climate forecast scenarios is represented by the expected net returns obtained from using the decision rules from the reconvened focus group. The difference in expected annual net returns between the two scenarios is the expected value of the climate forecasts.

Annual net returns per section for given current forage conditions i and forecast year j is

$$\mathrm{NR}_{ij} = \mathrm{RevCows}_{ij} + \mathrm{RevCalves}_{ij} - \mathrm{TVC}_{ij} + \mathrm{Interest}_{ij} + \mathrm{EndInv}_{ij} - \mathrm{BegInv}_{ij} \quad (1)$$

where NR_{ij} equals the annual net returns per section over specified costs, the subscript i denotes one of the three base years, the subscript j denotes the forecast year, $\mathrm{RevCows}_{ij}$ is net revenue from cows, $\mathrm{RevCalves}_{ij}$ is net revenue from calves, TVC_{ij} is total variable costs, $\mathrm{Interest}_{ij}$ is net interest revenue, EndInv_{ij} is the value placed on animals in the herd at the end of the year, and BegInv_{ij} is the value of the herd at the beginning of the year. Net returns are calculated for the annual period of 1 October–30 September.

$\mathrm{RevCows}_{ij}$ is the revenues and costs associated with changes in the stocking rates and culling and replacement decisions. Two stocking-rate decision points are included in the model. The October decision point is based on either Lee's (1999) prior information decision rules or the revised rules based on the forage forecasts. A July decision point is also included in the model, but stocking rate decisions are only based on Lee's (1999) rules. $\mathrm{RevCalves}_{ij}$ is the revenues and costs associated with purchasing (increase in stocking rate) or selling (decrease in stocking rate) calves in July and the net revenue from the autumn sale of weaned calves. At the July decision point it is assumed that if the stocking rate is increased, a cow–calf pair is bought. If the stocking rate is decreased, cows without calves are sold first, then cows with calves are sold to reach the desired stocking rate. Prices for calves are based on estimated price equations that include climate variables and beef-cow inventory numbers as independent variables. These equations allow for the impact of climate variability and cattle price cycles on the price of the calves.

TVC_{ij} is based on variable costs per head; therefore, variable costs differ by stocking rate. Variable costs include range cubes, salt and minerals, veterinary medicine, fuel, lubrication, repairs, and miscellaneous costs, along with hauling and commission costs per head sold. An interest charge is added to the variable costs based on the assumption that operating loans are used. $Interest_{ij}$ consists of interest earned on revenue from the sale of cows and calves (assuming the revenue is reinvested) minus interest charges on capital used to restock (assuming an opportunity cost for the capital). Last, $BegInv_{ij}$ and $EndInv_{ij}$ are included to account for changes in inventory over the year.

For each current condition, NR_{ij} is calculated for all years within a forecast category. Each NR_{ij} is weighted by the appropriate joint probability of occurrence of the current condition and forecast to obtain the expected value of annual net returns. Equation (1) for NR_{ij} is used to calculate both the prior-information and the with-climate-forecasts net returns. The only difference between the prior-information and with-forecasts models is the decision rules used (see the results section below) in generating animal performance. It is assumed each historical year in the dataset is equally likely and the forecasts are reliable.

e. Decision rules and climate scenarios

As discussed earlier, two different sets of decisions were obtained from the focus group. No-uncertainty decision rules were obtained using three graphs similar to Fig. 2. Recall in the use of these graphs, the ranchers were told to assume the forecast years as graphed were certain to occur. Uncertainty rules were based on nine graphs similar to Fig. 3. Here, a range of possible outcomes may occur for each forecast.

The no-uncertainty rules are used under two assumptions on the possible years that can occur. In the "representative-years" scenario, there are nine possible climate combinations. Each of the above-average, typical, and below-average current years is followed by a forecast with no uncertainty for an above-average, typical, and below-average representative forage year (corresponds to Fig. 2 and related graphs). In the "all-years" scenario, all 49 yr in the dataset are used with each current year's condition, giving 147 possible combinations. Each of the above-average, typical, and below-average current years is followed by a forecast for above-average, typical, and below-average forage production. Instead of being a forecast with certainty, however, each year classified in the forecast category has an equally likely chance of occurring. To clarify, consider an above-average forecast. Any 1 of the 12 forage years classified as above-average forage production can occur. The same holds true for the 22 typical and 15 below-average years. The uncertainty decision rules are applied only to the all-years scenario. Three decision rule–forage year scenarios are therefore used: 1) no uncertainty–representative years, 2) no uncertainty–all years, and 3) uncertainty–all years.

3. Results

The first objective of this research is to determine what factors may affect the use of seasonal climate forecasts in ranching; determining the potential value of the use of such forecasts is the second objective. Comments concerning the use of climate forecasts from the focus-group meeting are presented for both the initial and follow-up focus-group meetings. Then, changes in stocking-rate decisions based on the availability of climate forecasts are presented. Last, the estimated expected values of the use of the climate forecasts are presented.

a. Focus group

1) Factors affecting the decision-making process

The focus group deemed weather the single most important factor in their business. However, forage production forecasts would be only one of the many factors influencing ranchers' decisions. The focus group concluded ranchers in the study area use conservative practices and tend to manage for drought conditions. Ranchers are more likely to react to a forecast for poor conditions than to forecasts for favorable forage conditions. The current year's range conditions will be considered in the decision-making process. If current forage is scarce, ranchers are more likely to keep the herd size the same or to decrease the stocking rate to improve the range conditions, even if favorable conditions are forecast. Previous and current stocking rates will also affect how decision makers use climate forecasts to adjust stocking rates.

Feed and livestock price cycles also influence stocking rates. High cattle and feed prices may force ranchers to decrease their herd size regardless of the forecast. Low cattle and feed prices may entice ranchers to increase their stocking rates depending on their risk-aversion level. Interest rates and the availability of credit to the rancher also will influence a rancher's decisions.

2) Additional focus-group comments

The focus group noted today's rancher cannot operate as the traditional rancher once did. To remain competitive, one has to be willing to incorporate information into one's operations. The ranchers would not base their stocking rates only on the climate information that is currently available to them. Current forecasts are too uncertain and cover regions that are too broad. The forecasts would need to be more site-specific and accurate to be incorporated into their management practices. The forecasts would have to be 70% to 80% accurate and proven for a 4–5-yr period before the focus group would feel comfortable using them. Lead time of forecasts would also be crucial to be able to adjust operations accordingly.

Interest was expressed by the focus group in learning more about climate forecasts through training programs. They also thought other ranchers would like to be informed about climate forecasts. A weather research seminar was suggested as a forum to learn about the advancements taking place. Focus-group members consider west Texas to have a variable climate and realize any additional information they could obtain may be beneficial to their management practices. The ranchers also realized a potential to incorporate climate forecasts into their commercial deer-hunting operations to be able to time their hunts for more favorable weather conditions.

The focus group acknowledged that it is important for forecasts to be reported in a user-friendly form, but they also expressed concerns about making forage-production forecasts. The focus group believed it would be difficult to forecast forage production, because one would have to understand individual rancher's management practices and the diversity of each ranch's land. They expressed concern about the government using the forage forecasts to determine disaster relief. The focus group also was worried about ranchers being labeled as destroying the land if there is a forecast for below-average forage production. Instead of forage-production forecasts, the focus group would prefer to receive forecasts for rainfall and temperature.

3) Follow-up focus-group meeting

Upon receiving the results of the study, the focus group noted the study gave them many factors to consider. It is not a simple answer that seasonal climate forecasts are valuable and they will be used. Further, the panel felt the study team's interpretations of their decision rules for the forecast scenarios were reasonable.

Focus-group members felt ranchers would face different restocking and destocking prices regardless of climate conditions. Destocking price represents the value at which a rancher sells cows, whereas the restocking price is the price at which ranchers buy cows. Climate conditions would also play an important role in local cattle prices. In addition, the ranchers felt calving percentages may increase in the year following the use of a forecast, but they would not expect a significant increase in the calving percentage. The focus group felt decreasing their stocking rates, especially in a poor year that followed another poor year, would decrease their variable costs. For example, when faced with two below-average years of forage production in sequence, they felt the second year would be even worse than the first year in terms of forage growth. To compensate for the lack of forage, they would increase the amount of supplemental feed for their herd. Further, the focus group reconfirmed deer hunting is an important factor to ranching income in Sutton County. The ranchers noted if they did not respond to a below-current–below-forecast sequence by decreasing their stocking rate, deer populations on the ranch would decrease drastically. With no deer on the land, hunters would become disinterested, and income to the ranch would be lost. The forecasts could also be used for leasing property for deer hunting. Ranchers felt they could use a favorable forecast to promote the size of deer and possibly increase lease rates. Ranchers could also use a below-average forecast to entice hunters to increase supplemental feeding to maintain deer herds. The focus group noted, however, yearly changes in lease rates based on forecasts would be difficult if not impossible to administer.

The focus group discussed the personal and economic value associated with the genetics of their herds. For example, the ranchers felt pride in the work they do to develop quality in their herds through selective breeding. If they decrease stocking rates, the genetic history may be lost to the ranch. Preservation of genetic traits would play an important role in the use of climate forecasts. Last, panel members felt results may differ if sheep and goats were included in the economic model because of the diversity these animals bring to their ranching enterprises.

Focus-group participants again expressed interest in continued training programs to learn more about long-term forecasts because of their potential usefulness. Forecasts may be used for herd management, but they could also be used for other rangeland management practices. Forecasts could be used to plan burn schedules for brush control. A forecast for an above-average year, for example, would provide ranchers the choice to increase the stocking rate to take advantage of additional forage or to decrease (or not change) the stocking rate to allow additional forage to grow. Additional forage could be used as fuel for controlled burns for brush control.

4) Prior-information stocking rates

Stocking-rate decisions for the autumn decision point for the prior-information and with-seasonal-forage-forecasts cases are provided in Table 1. Based on Lee's (1999) stocking-rate decision rules, the ranch would have 38.20, 36.55, and 29.21 animal units per section before the autumn decision is made for above-average, typical, and below-average current-year conditions. Using the prior-information decision rules, which are based only on current conditions, the rancher would make no stocking-rate changes at the autumn decision point if above-average forage conditions had just been experienced. If typical conditions had just been experienced, the rancher would decrease the stocking rate (from 36.55

TABLE 1. Adjusted cattle stocking rates (in animal units per section) based on focus-group input with and without climate-forecast information.

Forecast	Current year's condition: Above average	Typical	Below average
Stocking rate before autumn decision is made			
	38.20	36.55	29.21
Autumn decision using prior information			
	38.20	31.66	34.10
Autumn decision with climate forecast—no uncertainly			
Above average	39.94	36.55	34.10
Typical	38.20	31.66	34.10
Below average	34.73	31.26	24.31
Autumn decision with climate forecast—uncertainty			
Above average	38.20	31.66	34.10
Typical	38.20	31.66	34.10
Below average	36.47	31.66	29.52

to 31.66 animal units per section), whereas if below-average conditions had been experienced, the stocking rate would be increased (from 29.21 to 34.10 animal units per section). Differences in deviations in forage production explain the changes. Although typical conditions have been experienced most of the year, at the end of the year, forage is decreasing, so the prior-information decision rules suggest a decrease in stocking rates. In the below-average case, at the end of the period, forage production is improving, warranting the increase in stocking rates.

5) NO-UNCERTAINTY STOCKING RATES

With a no-uncertainty forecast for above-average forage production following a year of above-average forage production, the ranchers' consensus is they would buy temporary stocker cattle and increase their stocking rates. The study team's interpretation of the panel's comments is the ranchers would increase their stocking rate from 38.20 animal units to 39.94 animal units. After experiencing typical conditions with an above-average forecast, the ranchers' consensus is not to change the stocking rate. This decision is an increase over the prior-information scenario. With below-average current conditions and an above-average forecast, there is no change in the autumn decision rule between the prior-information and the no-uncertainty cases. Regardless of the current conditions, a typical forecast resulted in no change in the autumn decision rules between the prior-information and the no-uncertainty cases. In all cases, a below-average forecast resulted in lower stocking rates than the prior-information case.

6) UNCERTAINTY STOCKING RATES

When presented with the uncertainty forage-production forecasts, the ranchers made only minor changes from their prior-information decisions, because of the increased variability associated with the forecasts. With forecasts for above-average and typical forage production, the focus group concluded they were not likely to make stocking-rate changes in their operations. On the other hand, when they were presented forecasts for a below-average forage production, the ranchers acknowledged they would be more inclined to use the forecast and to adjust their stocking rates to protect against losses. The decrease would not be as substantial as the no-uncertainty scenario, because of the uncertainty associated with the forecasts.

b. Value of seasonal forage-production forecasts

Results for all three decision-rules–forage-years scenarios are presented in Table 2 for various destocking prices. These expected values represent the increase in net returns per section from the use of the seasonal climate forecasts for the forecast (single) year only. As the destocking price decreases relative to the restocking price (set at $700 per cow), the information value per section increases in all three scenarios. In the no-un-

TABLE 2. Expected value of seasonal forage-production forecasts per section and percentage change in standard deviations of net returns for the no-uncertainty–representative-years, no-uncertainty–all-years, and uncertainty–all-years scenarios for various destocking prices, assuming a 300-lb Jul calf, and mean national inventory levels.*

Destocking price ($ per head)	Expected value: no uncert.–repres. years	Expected value: no uncert.–all years	% change in std dev: no uncert.–all years	Expected value: uncertainty–all years	% change in std dev: uncertainty–all years
700	−40.35	−46.12	15.8	−149.32	5.3
680	−20.61	−34.94	15.8	−138.87	4.5
660	−0.88	−23.79	15.8	−128.41	3.8
640	18.85	−12.63	15.7	−117.94	3.0
620	38.59	−1.46	15.7	−107.49	2.3
600	58.32	9.71	15.6	−99.86	1.5
500	156.99	65.54	15.1	−47.56	−1.8
410	245.79	115.78	14.5	−0.50	−4.3
400	255.66	121.35	14.4	4.73	−4.6

* Restocking price is set at $700 per cow. Abbreviations used are % for percent, uncert. for uncertainty, repres. for representative, and std dev for standard deviation. See text for definition of the different scenarios.

certainty–representative-years scenario, the expected value of the climate information becomes positive when the destocking price is approximately \$660 per head or 7% lower than the restocking price of \$700 per head. The value of the climate information becomes positive in the no-uncertainty–all-years scenario when the destocking price is approximately \$620, or 13%, lower than the restocking price. For the uncertainty–all-years scenario, the value of information becomes positive when the destocking price is approximately \$410, or 43%, lower than the restocking price.

The value of the climate information depends on changes in stocking rates that affect net interest, the number of calves sold, when calves are sold, variable costs, and revenues and costs associated with buying and selling cows. Increases in the value of the climate information occur when the destocking price is lower than the restocking price, because by using the climate forecasts ranchers reduce the variability of the expected number of cows purchased and/or sold (includes both October and July decision points). In the no-uncertainty–representative-years scenario, 1.62 fewer animal units per section are purchased and/or sold with the use of climate forecasts. In the no-uncertainty–all-years and uncertainty–all-years scenarios, 0.61 and 0.76 fewer animal units per section are purchased and/or sold with the use of climate forecasts. Differences in the value of the forecasts occur because of the penalty (or transaction costs) associated with selling cows at a price lower than the price at which the cows are purchased.

Percent changes in the standard deviation of net returns between the prior-information and all-years scenarios are also included in Table 2. Standard deviations of net returns with climate forecasts in the no-uncertainty–all-years scenario are about 14.4%–15.8% higher than standard deviations of prior-information net returns. In the uncertainty–all-years scenario, standard deviations of net returns range from 4.6% lower to 5.3% higher than standard deviations of net returns associated with using only prior information. The negative percent change in the standard deviation denotes decreased variability in net returns. As the destocking price is lowered relative to the restocking price in both the no-uncertainty–all-years and uncertainty–all-years scenarios, the percent change in the standard deviations also decreases.

Sensitivity analysis on parameters besides destocking price can be summarized as follows. As the July calf weight increases, the value of the forecasts decreases. Similarly, as calf price increases (caused by changes in national cattle inventory numbers used in the price equations), the value of the forecasts decreases. Increases in both parameters increase the value of a calf in the model. This increase in calf value makes adjustments to the stocking rate more costly to the rancher.

To gain further insight into the value of the forecasts, Table 3 contains a breakdown of the expected value of the forecasts for the scenario for no uncertainty–all years for one price and one calf weight. In this example, no value is placed on the typical forecast because there are no changes to the decision rules. When above-average forecasts are received, the expected forecast year's net returns increase when either above-average or typical conditions have been experienced. Expected forecast year's net returns decrease when a below-average forecast is received, regardless of the current conditions. Increases in forecast year's expected net returns primarily result from increases in stocking rates, whereas the decrease in expected net returns is primarily a result of decreases in the stocking rate. Although, overall, expected net returns are negative in this example (−\$46.12 per section), some components have positive and others have negative expected values. This pattern of increases and decreases in expected net returns is generally consistent throughout the different scenarios. The magnitudes of the increases and decreases change, however, with changes in the parameters of the model.

TABLE 3. Expected value of seasonal forage-production forecasts per section by forecasts, assuming a 300-lb calf weight, and mean national inventory level for the no-uncertainty–all-years scenario assuming a \$700 per head restocking and destocking price.*

Forecast received	Current conditions: Above average	Typical	Below average	Expected value by forecast
Above average	15.91	212.27	0.00	228.18
Typical	0.00	0.00	0.00	0.00
Below average	−76.50	−6.72	−191.08	−274.30
Expected value by current condition	−60.59	205.55	−191.08	−46.12

* All values have been weighted by the appropriate probability of specific events occurring.

4. Discussion

Although the expected value of the seasonal production forecasts is potentially negative in the three scenarios, the economic value of the information is not necessarily negative. Many additional issues must be considered. Recall that the economic model is a 1-yr model. Increases in calving percentages and improved range conditions in years following the use of seasonal climate forecasts are not captured in the 1-yr model. The focus group felt calving percentages may increase by using the forecasts, but they would not expect large increases. Depending on the case given in Table 2, calving percentages would have to increase by 0.2%–1.8% to make the expected value of the forecasts positive. Further, by destocking when faced with forecasts for below-average forage production, the ranchers are giving up some returns today, but they are protecting the ecological condition of their ranch. This protection could easily make the expected value of the forecasts positive.

Supplemental feed costs are not included in the model because PHYGROW did not calculate shortfalls in dry-matter requirements. As noted earlier, the focus group felt they would have to increase both the quantity and quality of supplemental feed during below-average years. The use of forecasts may allow ranchers to lower their variable costs and to increase the expected value of the forecast information because of destocking during below-average forage-production years.

Deer-hunting and brush-control management are not in the biophysical–economic model. As noted by the focus group, inclusion of these activities may increase the expected value of the seasonal climate forecasts. Further, use of the climate forecasts may also help to maintain the genetics (quality) of both the cattle and deer herds.

Further studies need to address these issues, but inclusion of these issues is not a trivial task. Except possibly supplemental feed, these issues require a multiyear model. Including expanded forage dynamics, brush management, and cattle and deer herd dynamics requires a methodological approach that to our knowledge is not currently developed. In addition, a model that includes forecasts for periods shorter than one year should be developed, because of intrayear climate variability. This task would require the focus group to provide additional information concerning stocking-rate decision rules. Elicitation of multiperiod decision rules based on the use of climate forecasts requires further consideration, because of the lack of experience decision makers have with using climate forecasts. By design of the focus group presentation, the expected values may be upwardly biased. Recall that it is assumed the conditions being forecasted will occur.

The focus group was concerned that issuing forage forecasts could or would be misused by some groups as an indication of poor ranch-management practices rather than weather-related conditions. This concern suggests other forms of forecasts such as rainfall and/or temperature forecasts should be used to elicit feedback from decision makers. More important, this concern suggests the notion of user-friendly forecasts needs further consideration.

Several final comments are warranted. First, comparison of the different decision rule–climate scenarios illustrates that only considering representative outcomes potentially biases the expected value of the forecasts. Second, the focus group mentioned they were conservative. Their responses and revised decision rules confirm this statement. Third, this study is unique in its attempt to value information based on focus groups rather than on strictly model-based decisions. This approach allows impediments to the use of seasonal forecasts to be identified. It is not a simple case of the forecasts having value so therefore they will be used. However, the value of the forecasts is specific to the decision rules developed using the focus group input. Fourth, estimated value of the forecasts are for seasonal forage forecasts. These values may overstate the value of seasonal temperature and rainfall forecasts because of the lack of a one-to-one correspondence of such forecasts to forage forecasts. Last, as noted by several authors and reinforced by the focus group, education–outreach programs are necessary if the potential net benefits from the use of seasonal climate forecasts are to be realized. Dissemination and use of forage forecasts, however, through face-to-face meetings between researchers and decision makers would be cost prohibitive. Development of effective education and outreach programs, taking both the costs of such programs and benefits received into account, would be an interesting next avenue of research and development.

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